

**SAMSUNG DISPLAY**

Product Specification

() Preliminary Specification

(√) Approval Specification

Any Modification of Spec is not allowed without SDC's permission.

CUSTOMER		MODEL NO.	LTN156AT32
DATE OF ISSUE	2013.04.02	EXTENSION CODE	-L01

Customer Approval & Feedback	

Approved by	
Prepared by	
LCD Sales & Marketing Team Samsung Display Co., Ltd	

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1. GENERAL DESCRIPTION

DESCRIPTION

The LTN156AT32-L01 uses a color active matrix TFT (Thin Film Transistor) liquid crystal display (LCD) that uses amorphous silicon TFTs as switching components. This model is composed of a TFT LCD panel, a driver circuit, and a backlight unit. This 15.6" model has a resolution of 1366 x 768 pixels and can display up to 262,144 colors.

FEATURES

High contrast ratio
HD (1366 x 768 pixels) resolution
Low power consumption
Fast Response
LED back light with an embedded LED driver
DE (Data enable) only mode
3.3V LVDS Interface
Onboard EDID chip

APPLICATIONS

Notebook PC
If the intent to use this product is for other purpose, please contact Samsung Display.

GENERAL INFORMATION

Item	Specification	Unit	Note
Display area	344.232 (H) x 193.536 (V) (15.6"diagonal)	mm	
Driver Element	a-Si TFT active matrix		
Display colors	262,144 (6bit)		
Number of pixel	1366 *768(HD)	Pixel	16:9
Pixel Arrangement	RGB vertical stripe		
Pixel pitch	0.252 (H) x 0.252 (V) (TYP.)	mm	
Display Mode	Normally white, TN mode		
Thickness of glass	0.5	mm	
Surface treatment	Haze 0, Hardness 3H		Glare
Environmental safe regulation	Pb Free, Halogen Free		
Power Consumption	Total 4.16W(Typ) @Logic 0.7W(Typ) BLU 3.46W (Typ) Total 4.4W(Max)		Mosaic PTN



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MECHANICAL INFORMATION

Item		Min.	Typ.	Max.	Unit	Note
Module Size	Horizontal (H)	358.8	359.3	359.8	mm	
	Vertical (V)	209.0	209.5	210.0	mm	
	Depth (D)	-	5.0	5.5	mm	(1)
Weight		-	440	450	g	

NOTE (1) Measuring method for thickness

Force to be applied for measurement (Panel body) : by using the micrometer.

Force to be applied for measurement (PCB side) : The 50gf when using the height gauge.

www.panelook.com

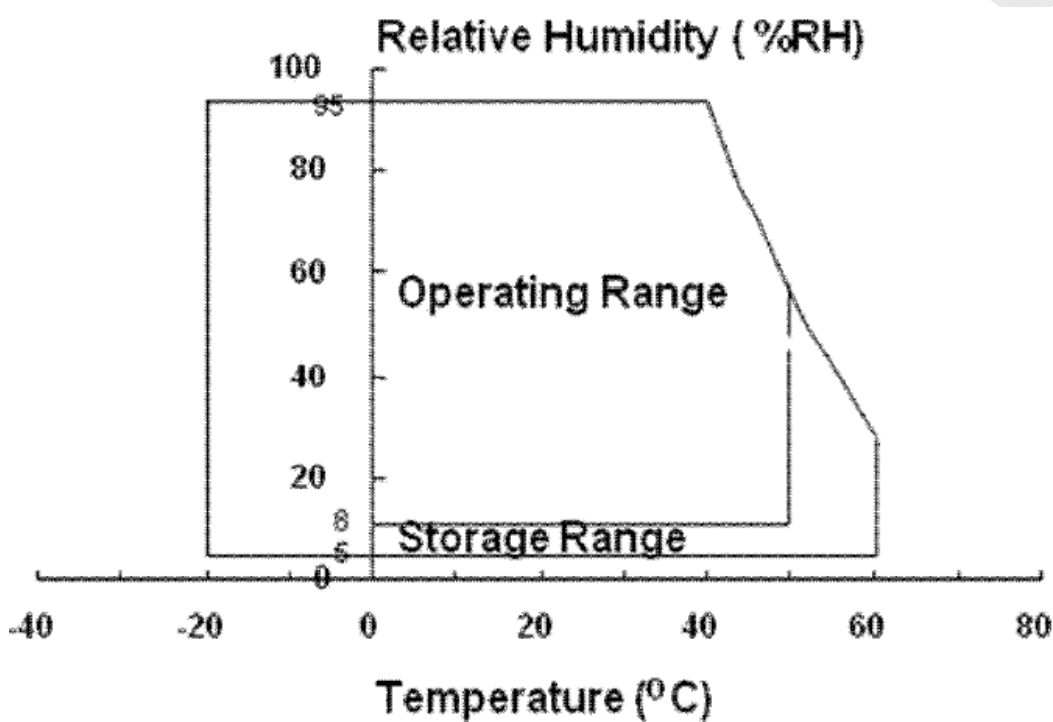
2. ABSOLUTE MAXIMUM RATINGS

2.1 ENVIRONMENTAL ABSOLTE RATINGS

Item	Symbol	Min.	Max.	Unit	Note
Storage temperate	TSTG	-20	60	°C	(1)
Operating temperature (Temperature of glass surface)	TOPR	0	50	°C	(1)
Shock (non-operating)	Snop		240	G	(2), (4)
Vibration (non-operating)	Vnop		2.41	G	(3), (4)

Note (1) The range of temperature and relative humidity are shown in the graph below 95% RH Max. .

(39°C ≥ Ta) If the temperature is higher than 40 °C, the maximum temperature of wet-bulb shall be less than 39°C. No condensation



(2) Vibrate $\pm X$, $\pm Y$, and $\pm Z$ axis in the shape of the half sine wave one time for 2ms .

(3) Vibrate the X, Y, and Z randomly within a 5 - 500 Hz range for 30min.

(4) When testing a vibration and a shock, the fixture, which holds the module to be tested shall be hard and rigid in order for the the module not to be twisted or bent by the fixture.

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2.2 ELECTRICAL ABSOLUTE RATINGS

(1) TFT LCD MODULE

 $V_{LCD_VCC} = 3.3V$, $V_{SS} = GND = 0V$

Item	Symbol	Min.	Max.	Unit	Note
Power Supply Voltage	V_{LCD_VCC}	$V_{SS} - 0.3$	4.0	V	(1),(2)
LVDS Input Voltage	V_{LVDS}	$V_{SS} - 0.3$	2.0		

Note (1) Within T_a (25 ± 2 °C)

(2) Permanent damage to the device may occur if exceed maximum values

(2) BACKLIGHT UNIT

 $V_{SS} = GND = 0V$

Item	Symbol	Min.	Max.	Unit	Note
BLU Supply Voltage	V_{BL_PWR}	$V_{SS} - 0.3$	26.5	V	(1), (2)
BLU Supply Current	I_{BL_PWR}	-	0.96	A	(1), (2) $V_{in}=12V$ Duty 100%

Note (1) Within T_a (25 ± 2 °C)

(2) Permanent damage to the device may occur if exceed maximum values

2.3 THE OTHERS

(1) STATIC ELECTRICITY PRESSURE RESISTANCE

Item	Test Conditions	Remark
CONTACT DISCHARGE	150pF, 330Ω, ± 8kV, 200points, 1 time/point	Operating
AIR DISCHARGE	150pF, 330Ω, ± 15kV, 200points, 1 time/point	Operating

3. OPTICAL CHARACTERISTICS

The following items are measured under the stable conditions.* The optical characteristics should be measured in the dark room or the equivalent environment by the methods shown in the Note (5).

Measuring equipment : TOPCON SR-3

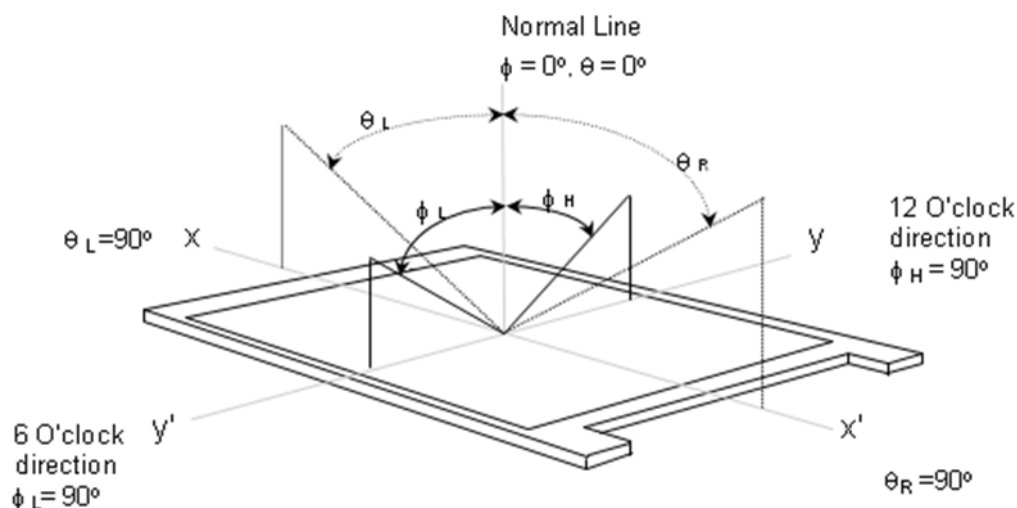
$T_a = 25 \pm 2 ^\circ\text{C}$, $V_{\text{LCD_VCC}} = 3.3\text{V}$, $f_v = 60\text{Hz}$, $f_{\text{DCLK}} = 72.33\text{MHz}$, $\text{IF} = 100\%$ duty

Item		Symbol	Condition	Min.	Typ.	Max.	Unit	Note
Contrast Ratio		CR	Normal Viewing Angle $\phi = 0$ $\theta = 0$	300	500	-	-	(1),(2),(5)
Response time (Rising + Falling)		T_{RT}		-	16	25	msec	(1),(3)
Average Luminance of White (5 Points)		$Y_{\text{L,AVE}}$		190	220	-	cd/m^2	IF=100% Duty (1),(4)
Color Chromaticity (CIE)	Red	R_x		-0.03	0.619	+0.03		(1),(5)
		R_y			0.350			
	Green	G_x			0.340			
		G_y			0.600			
	Blue	B_x			0.154			
		B_y			0.095			
	White	W_x			0.313			
		W_y			0.329			
Viewing Angle	Hor.	θ_L	$\text{CR} \geq 10$ At center	40	45	-	Degrees	(1),(5)
		θ_H		40	45	-		
	Ver.	ϕ_H		10	15	-		
		ϕ_L		30	35	-		
Color Gamut		CG		-	60	-	%	
White variation		δ_L	13P	-	-	1.66		(6)
			5P			1.25		

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Note (1) The definition of viewing angle: The range of viewing angle ($10 \leq C/R$)

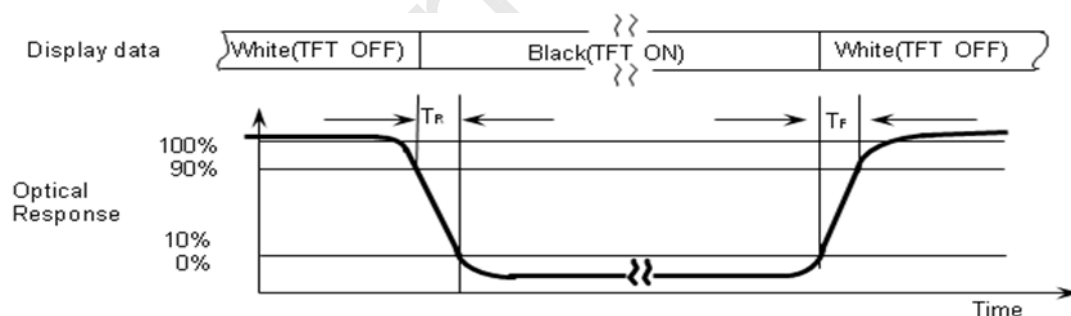


Note (2) The definition of contrast ratio (CR): The ratio of max. gray and min gray at 5 points (4, 5, 7, 9, and 10)

$$CR = \frac{CR(4) + CR(5) + CR(7) + CR(9) + CR(10)}{5}$$

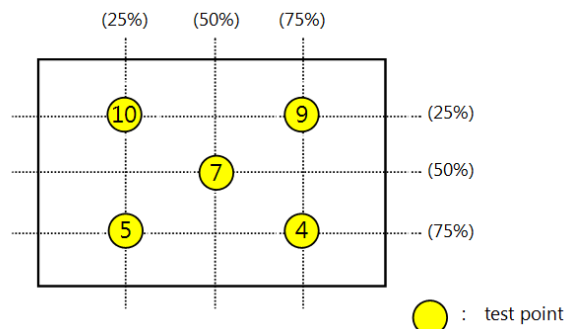
Points = ④, ⑤, ⑦, ⑨, ⑩ at the figure of Note(6).

Note (3) The definition of Response time: Subtotal of the time, during which the transmission changes from 10% to 90% when the TFT turns on and off.



Note (4) The definition of average luminance of white: Measure the luminance of white at 5 points.

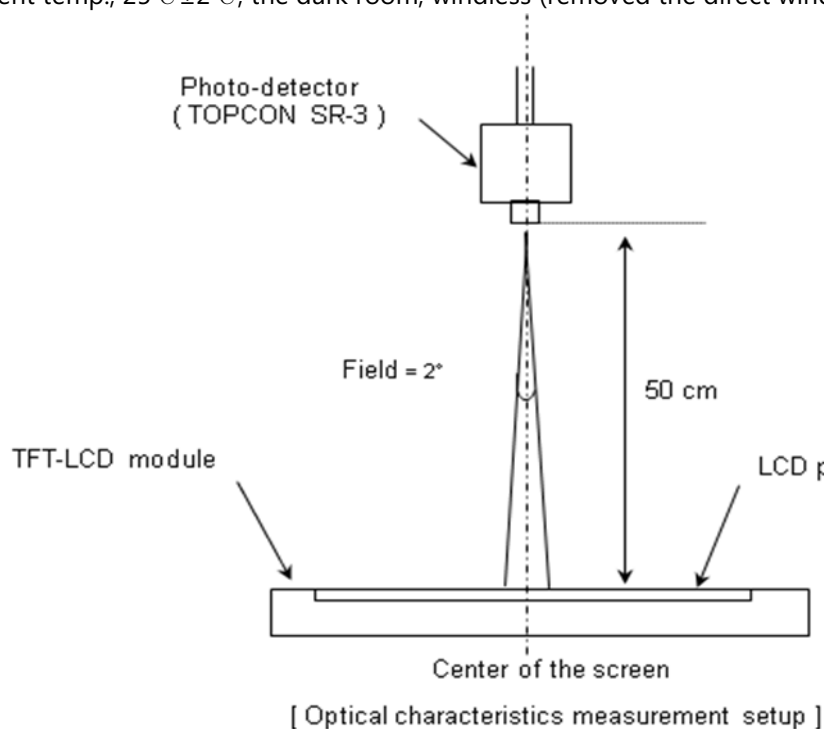
$$YL_{AVE} = \frac{YL4 + YL5 + YL7 + YL9 + YL10}{5}$$



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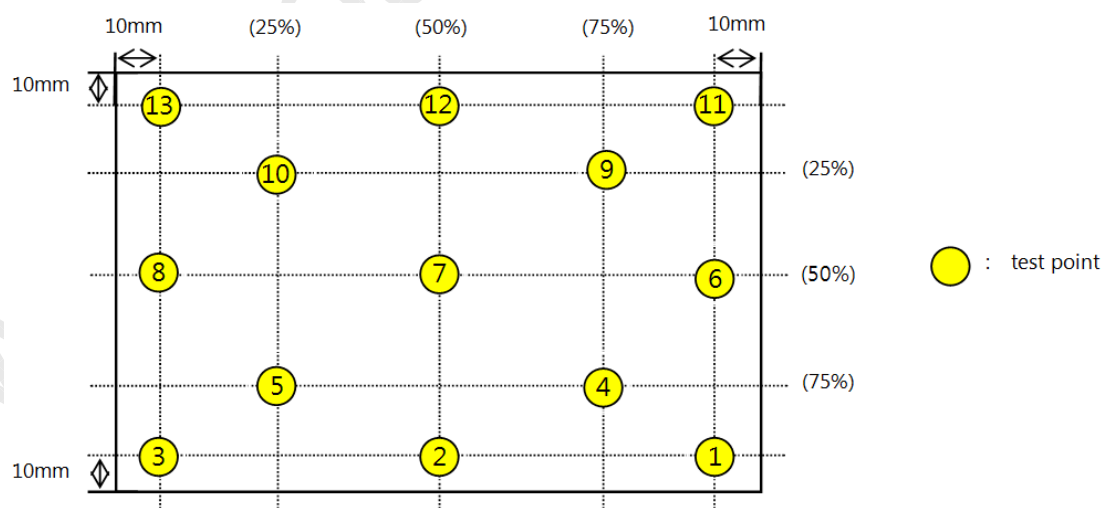
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Note (5) Measure the panel, which is left for 30 min. at the normal temp. after leaving it for 30 min with turning the back light on at the rating. The measurement should be executed under the condition including the ambient temp., $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$, the dark room, windless (removed the direct wind), and no vibration.



Note (6) The definition of white variation at 13 points (δL)

$$\delta L = \frac{\text{Maximum luminance of 13 points}}{\text{Minimum luminance of 13 points}}$$

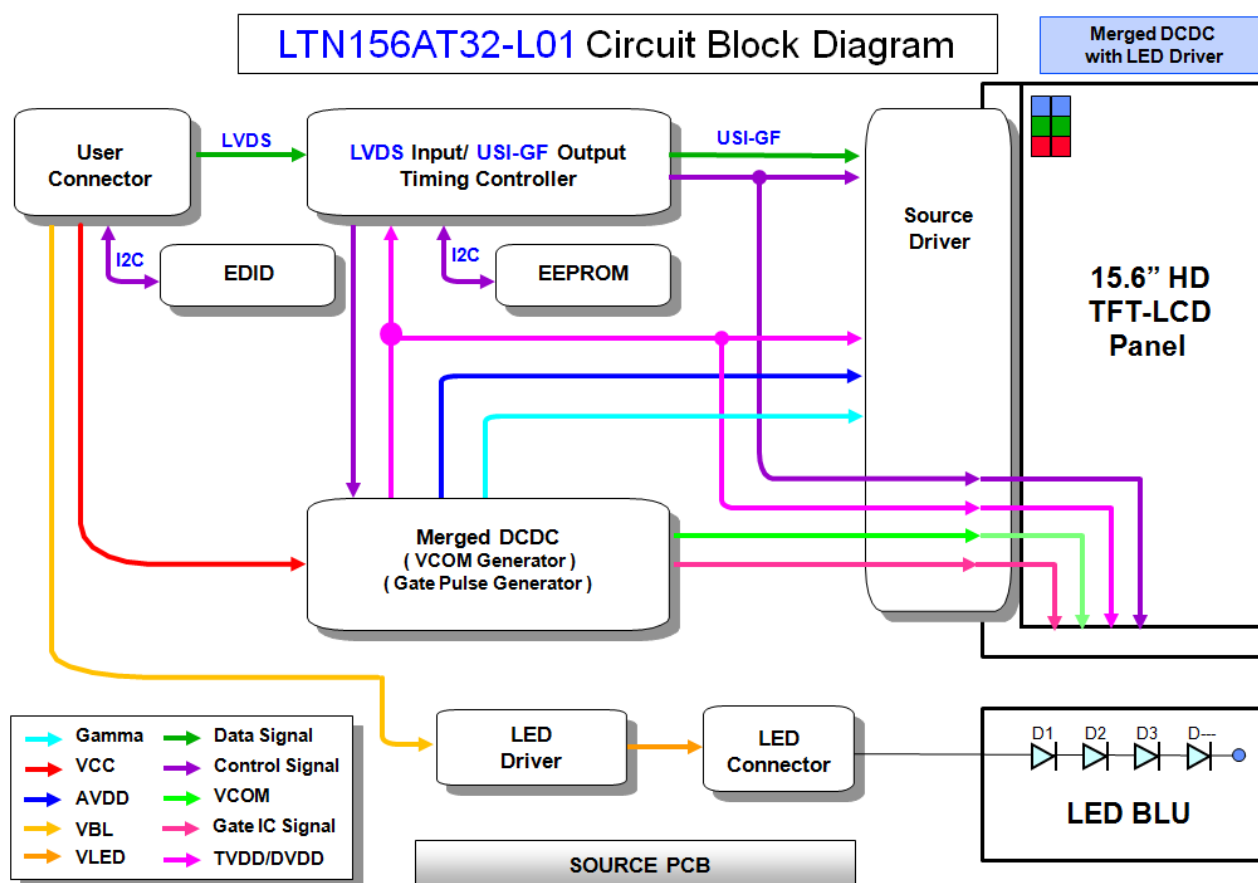


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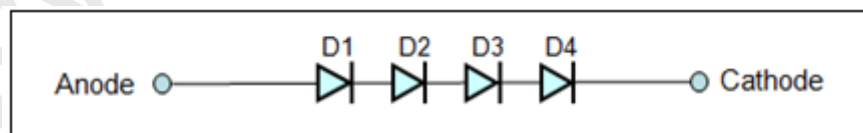
4. BLOCK DIAGRAM

4.1 TFT LCD MODULE



4.2 THE STRUCTURE OF LED PLACEMENT

(4 channel x 1ea = 4ea)



5. ELECTRICAL CHARACTERISTICS

5.1 TFT LCD MODULE

Item		Symbol	Min.	Typ.	Max.	Unit	Note
Power Supply Voltage		V_{LCD_VCC}	3.0	3.3	3.6	V	
T-CON TTL Input Voltage	High	V_{IH}	0.7 V_{LCD_VCC}	-	-	V	(1)
	Low	V_{IL}	-	-	0.3 V_{LCD_VCC}	V	
Vsync	60Hz	f_V	-	60	-	Hz	(3)
	50Hz	f_V	-	50	-	Hz	
	40Hz	f_V	-	40	-	Hz	
Hsync	60Hz	f_H	46.50	47.40	48.60	kHz	
Main Frequency	60Hz	f_{DCLK}	67.24	72.33	83.88	MHz	(3)
	50Hz	f_{DCLK}	-	60.28	-	MHz	
	40Hz	f_{DCLK}	-	48.22	-	MHz	
Rush Current		I_{RUSH}	-	-	1.5	A	(6)
Input Current	White	I_{LCD_VCC}	-	220	-	mA	(2), (5)
	Mosaic	I_{LCD_VCC}	-	220	-	mA	
	Black	I_{LCD_VCC}	-	220	-	mA	
	V.Stripe	I_{LCD_VCC}	-	400	450	mA	

* $T_a = 25 \pm 2^\circ\text{C}$

Note (1) The data pins for display and signal pins for timing should be connected. (GND= 0V)

(2) $f_V = 60\text{Hz}$, $f_{DCLK} = 72.33\text{MHz}$, $V_{LCD_VCC} = 3.3\text{V}$, DC Current.

(3) In the case of 40Hz & 50Hz for sDRRS, FOS,

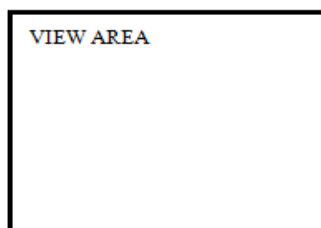
Flicker & Brightness are not guaranteed, because their level might be different from 60Hz operation.

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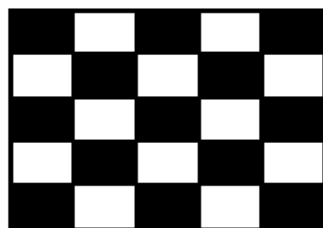
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Note (4) The dissipation pattern for power

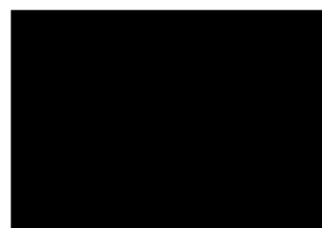
*a) White Pattern



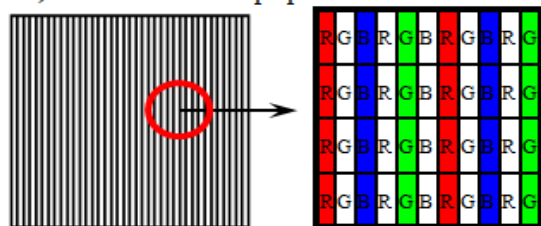
*b) Mosaic Pattern



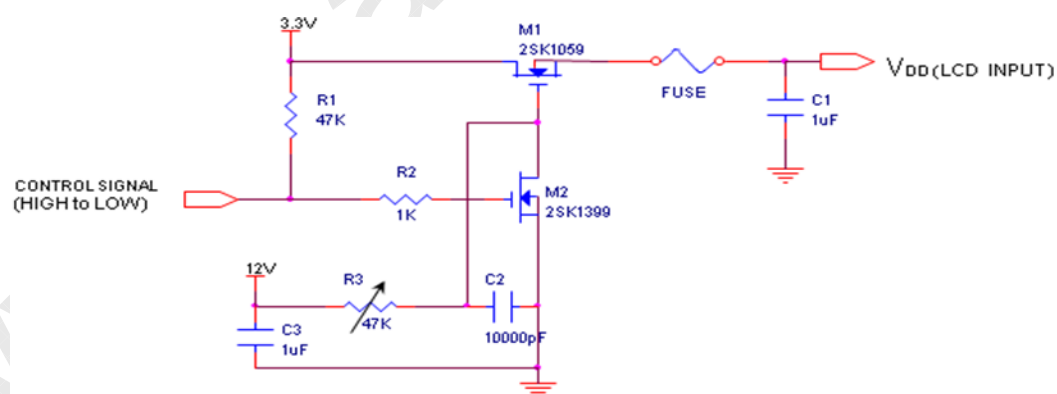
*c) Black Pattern



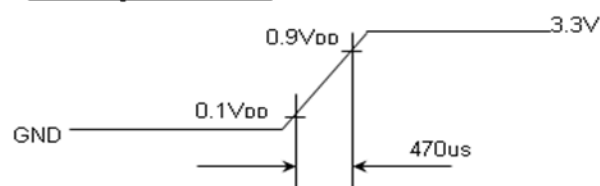
*d) 1 dot Vertical stripe pattern



Note (5) The condition for measurement for rush current



V_{DD} rising time is 470us



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5.2 BACK LIGHT UNIT

Ta = 25 ± 2 °C

Item	Symbol	Min.	Typ.	Max.	Unit	Note
LED Forward Current	IF	-	115	-	mA	
LED Forward Voltage	VF	6.1	6.4	6.7	V	IF = 115mA
LED Array Voltage	VP	-	25.6	-	V	
LED Power Consumption	P	-	3.46	3.6	W	
LED Life time	Hr	15,000			Hour	(1)
LED Counts	Q		4		EA	

Note (1) The life time (Hr) of LEDs can be defined as the time during which it continues to operate under the condition, which the Ta is 25 ± 2 °C and IF= 115.0 mArms until the one of the following events occurs when the brightness becomes 50% or lower than the original.

5.3 LED DRIVER

The manufacturer of LED driver: Richtek RT8510

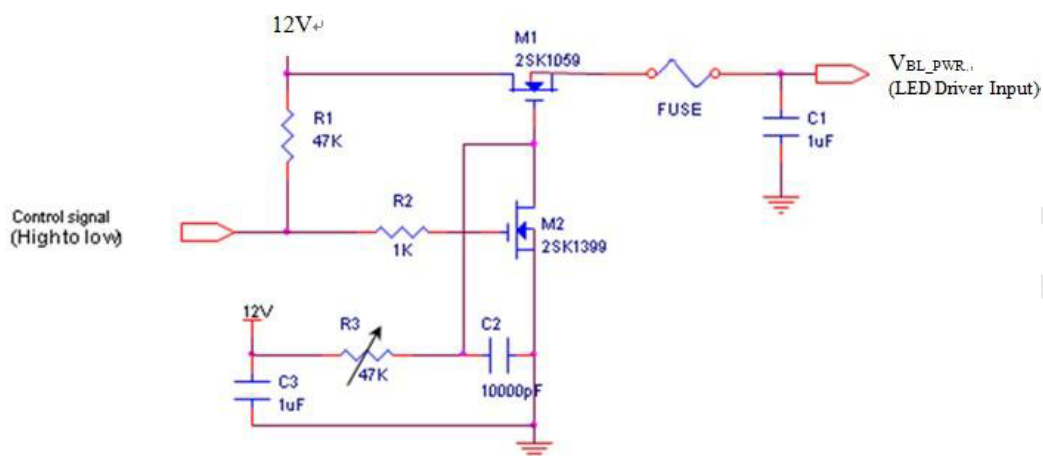
Ta= 25 ± 2 °C

Item		Symbol	Min.	Typ.	Max.	Unit	Note
Input Voltage		V _{BL_PWR}	5	12	21	V	
Input Current		I _{BL_PWR}	-	289	300	mA	Vin=12V Duty 100%
PWM duty Ratio		D _{BL_PWM_DIM}	1	-	100	%	
External PWM Frequency		F _{BL_PWM_DIM}	0.2	1	2	kHz	APS ON
			0.12	1	2	kHz	APS OFF
PWM Resolution		R _{BL_PWM_DIM}	0.8	-	-	%	APS ON
			0.3			%	APS OFF
In-Rush Current		I _{RUSH_BL_PWR}	-	-	1.5	A	(1)
EN Control Level	High	V _{BL_ENABLE}	2.0	-	5.0	V	
	Low		0.0	-	0.8	V	
PWM Control Level	High	V _{BL_PWM_DIM}	2.0	-	5.0	V	
	Low		0.0	-	0.8	V	
VBL_PWR @ LED Driver On		V _{BL_PWR}	7	-	21	V	
VBL_PWR @ LED Driver Off		V _{BL_PWR}	0	-	2	V	
Operating frequency		FO	0.8	1.0	1.2	kHz	
Efficiency		η	-	85	-	%	

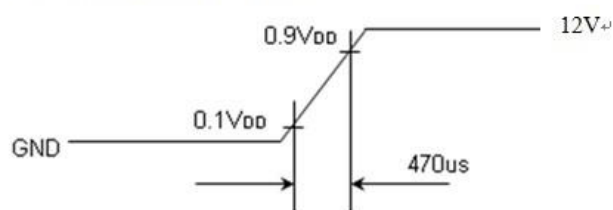
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Note (1) Rush current measurement condition



The V_{BL_PWR} rising time is 470us.



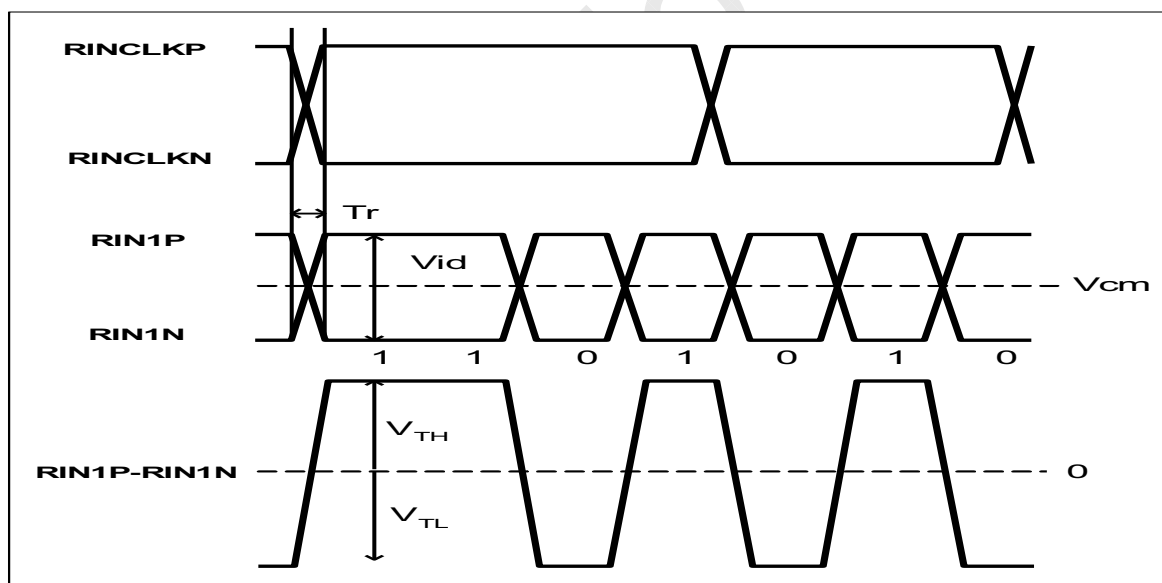
5.4 LVDS INTERFACE

LVDS DC Specifications

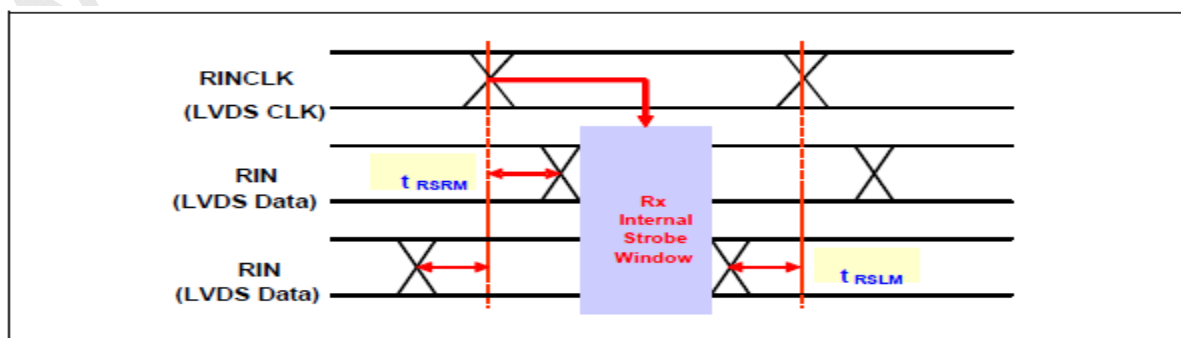
Characteristics	Symbol	Min.	Typ.	Max.	Unit	Conditions
Differential input high threshold voltage	V_{TH}	-	-	+200	mV	$V_{CM} = 1.2V$
Differential input low threshold voltage	V_{TL}	-200	-	-	mV	
Differential input voltage	$ V_{ID} $	200	400	600	mV	
Common mode voltage	V_{CM}	0.4	1.2	1.8	V	$ V_{ID} = 200mV$

LVDS AC Specifications

Characteristics		Symbol	Min.	Typ.	Max.	Unit	Remarks
ROUTCLK frequency		fRCP	67.24	72.33	83.88	Mhz	
LVDS RX Skew (Strobe) Right Margin	85MHz	T _{RSRM}	-	-	400	ps	
	50MHz		-	-	700	ps	
LVDS RX Skew (Strobe) Left Margin	85MHz	T _{RSLM}	-400	-	-	ps	
	50MHz		-700	-	-	ps	



< The definition of LVDS DC characteristics >



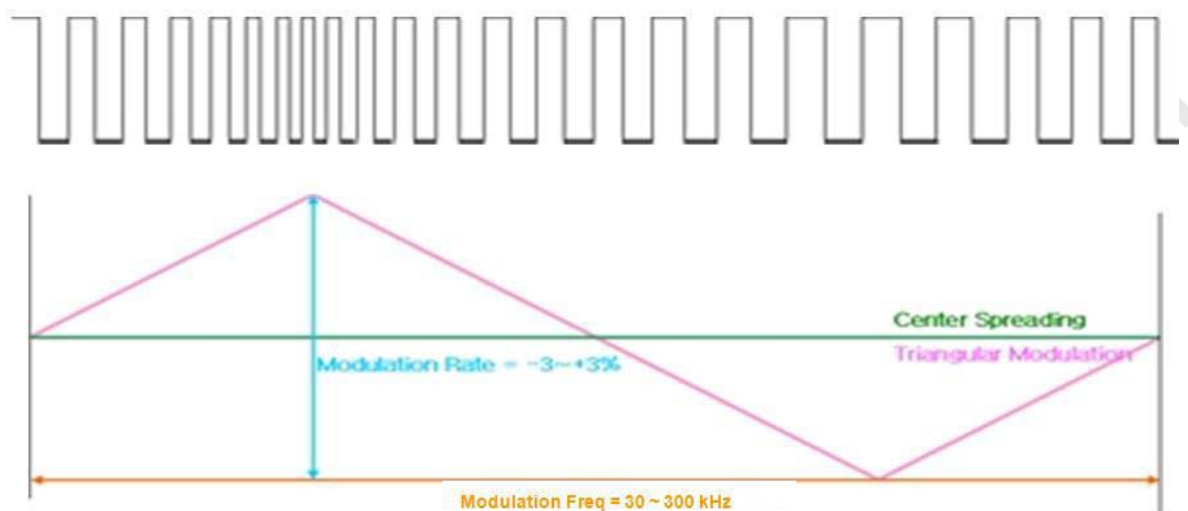
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< The definition of LVDS Receiver Skew (Strobe) Margin >

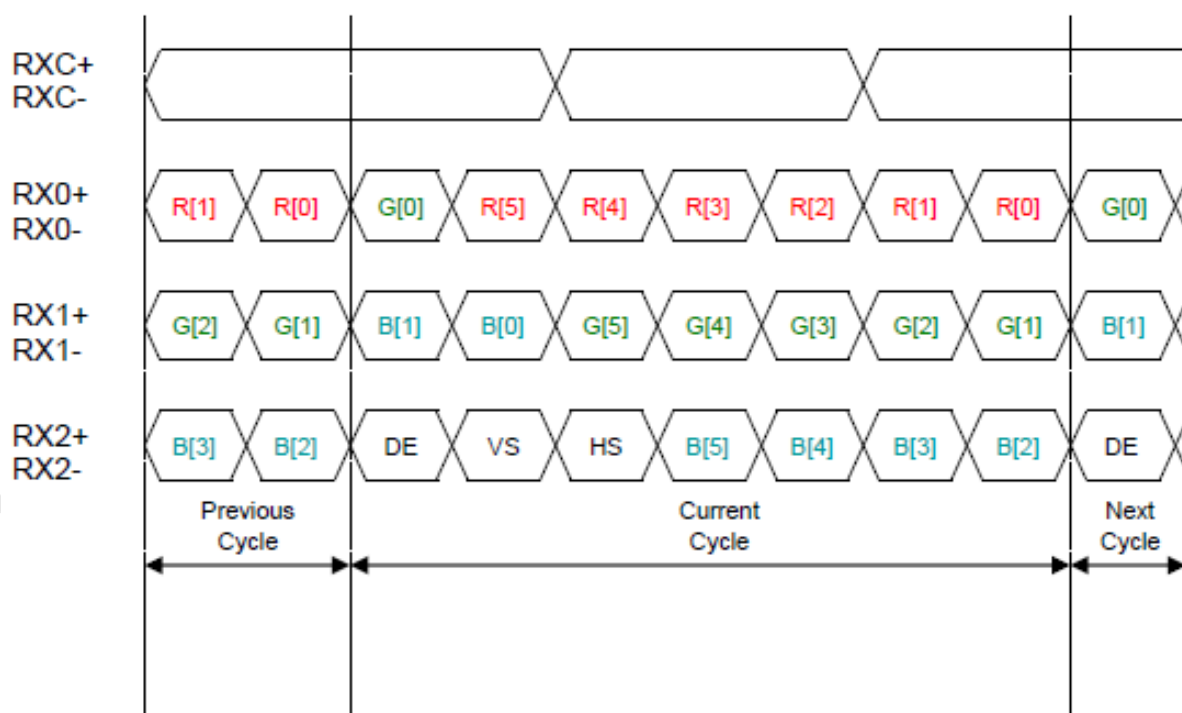
LVDS SSC Specification

Characteristics	Symbol	Min.	Typ.	Max.	Unit	Remarks
Modulation Rate	Fmr	-3	0	+3	%	
Modulation Frequency	Fmf	30	-	300	kHz	@ MAINCLK = 72.33MHz



< Definition of SSC (Spread Spectrum Clock) >

Timing diagrams of LVDS transmission

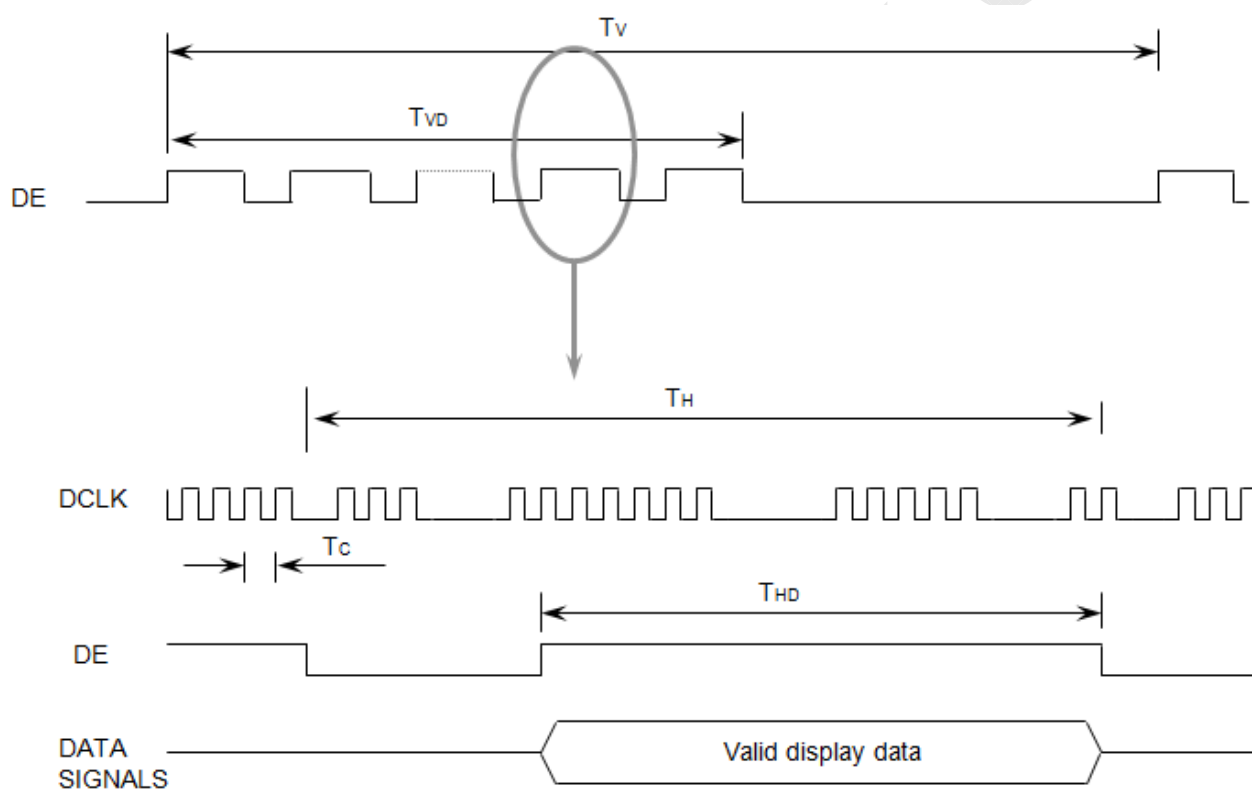


5.5 INTERFACE TIMING

5.5.1 TIMING PARAMETERS

Signal	Item	Symbol	Min.	Typ.	Max.	Unit	Note
Frame Frequency	Cycle	T_V	775	790	810	Lines	
Vertical active in the display term	Display Period	T_{VD}	-	768	-	Lines	
Scanning time in one line	Cycle	T_H	1446	1526	1726	Clocks	
Horizontal active in the display term	Display Period	T_{HD}	-	1366	-	Clocks	

5.5.2 TIMING DIAGRAMS OF INTERFACE SIGNAL



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5.6 INPUT COLOR DATA MAPPING

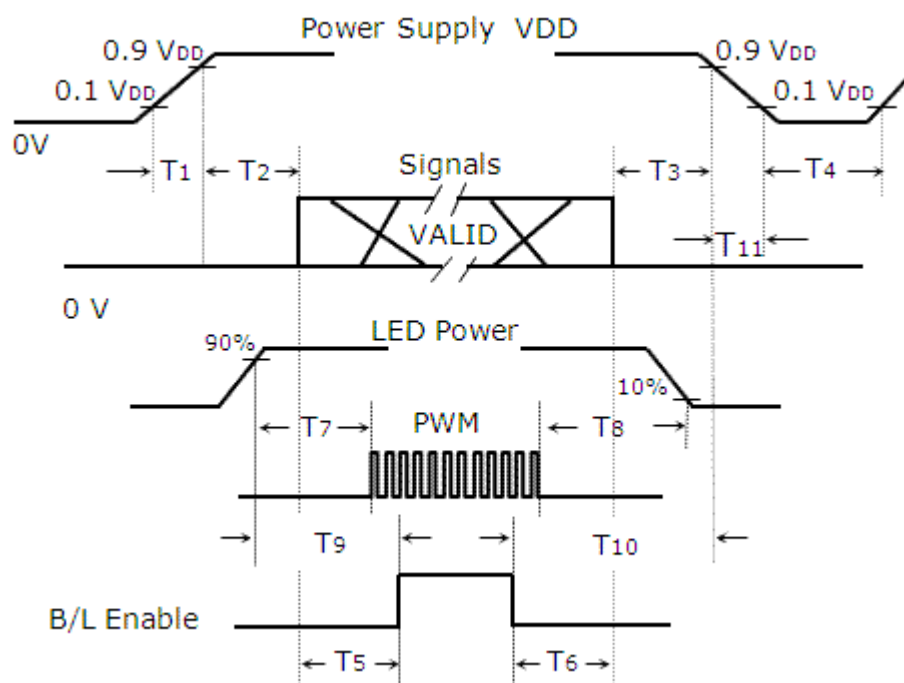
Color	Display	Data Signal																	Gray Scale Level	
		Red						Green						Blue						
		R0	R1	R2	R3	R4	R5	G0	G1	G2	G3	G4	G5	B0	B1	B2	B3	45		B5
Basic Colors	Black	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-
	Blue	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	-
	Green	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	-
	Cyan	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	-
	Red	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	-
	Magenta	1	1	1	1	1	1	0	0	0	0	0	0	1	1	1	1	1	1	-
	Yellow	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	-
	White	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-
Gray Scale Of Red	Black	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	R0
	Dark	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	R1
	↑	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	R2
	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	R3~R60
	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	
	↓	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	R61
	Light	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	R62
	Red	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	R63
Gray Scale Of Green	Black	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	G0
	Dark	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	G1
	↑	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	G2
	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	G3~G60
	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	
	↓	0	0	0	0	0	0	1	0	1	1	1	1	0	0	0	0	0	0	G61
	Light	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	G62
	Green	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	G63
Gray Scale Of Blue	Black	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	B0
	Dark	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	B1
	↑	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	B2
	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	B3~B60
	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	
	↓	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	B61
	Light	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	B62
	Blue	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	B63

Note (1) Definition of gray : Rn: Red gray, Gn: Green gray, Bn: Blue gray (n=gray level)

Note (2) Input signal: 0 =Low level voltage, 1=High level voltage

5.7 POWER ON/OFF SEQUENCE

To prevent the product from being latched up or the DC in the LCD module from starting an operation, the order to turn the power on and off should be changed to the order as shown in the diagram below.



Timing (ms)	Remarks
$0.5 < T_1 \leq 10$	V _{DD} rising time from 10% to 90%
$0 < T_2 \leq 50$	Delay from V _{DD} to valid data at power ON
$0 < T_3$	Delay from valid data OFF to V _{DD} off at power OFF
$150 \leq T_4$	V _{DD} OFF time for Windows restart
$200 \leq T_5$	Delay from valid data to B/L enable at power ON
$0 < T_6$	Delay from valid data off to B/L disable at power Off
$0 < T_7$	Delay from LED driver power ON to PWM ON
$0 < T_8$	Delay from PWM OFF to LED driver power OFF
$0 < T_9$	Delay from VBL on to B/L Enable ON
$0 < T_{10}$	Delay from B/L Enable Off to VBL OFF
$0.5 < T_{11} \leq 10$	V _{DD} Falling time from 90% to 10%



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The backlight may be flashed if the interface signal remains floated when the above-mentioned signal becomes invalid.

- Note
- (1) The power voltage from system shall be supplied to the input pin of LCD constantly.
 - (2) Enable the voltage to the LED within the range, which the LCD is operated. The screen becomes white when turning the back-light on before the LCD is operated or turning the LCD off before turning the back-light off. Operation or the LCD turns off before the back-light turns off, the display may momentarily become white.
 - (3) Don't leave the system at a high impedance state, which the interface signal is out for a long time after the Vcc is enabled.
 - (4) The T4 should be measured the module is fully discharged.
 - (5) The interface signal shall not maintain the high impedance when the power is on.

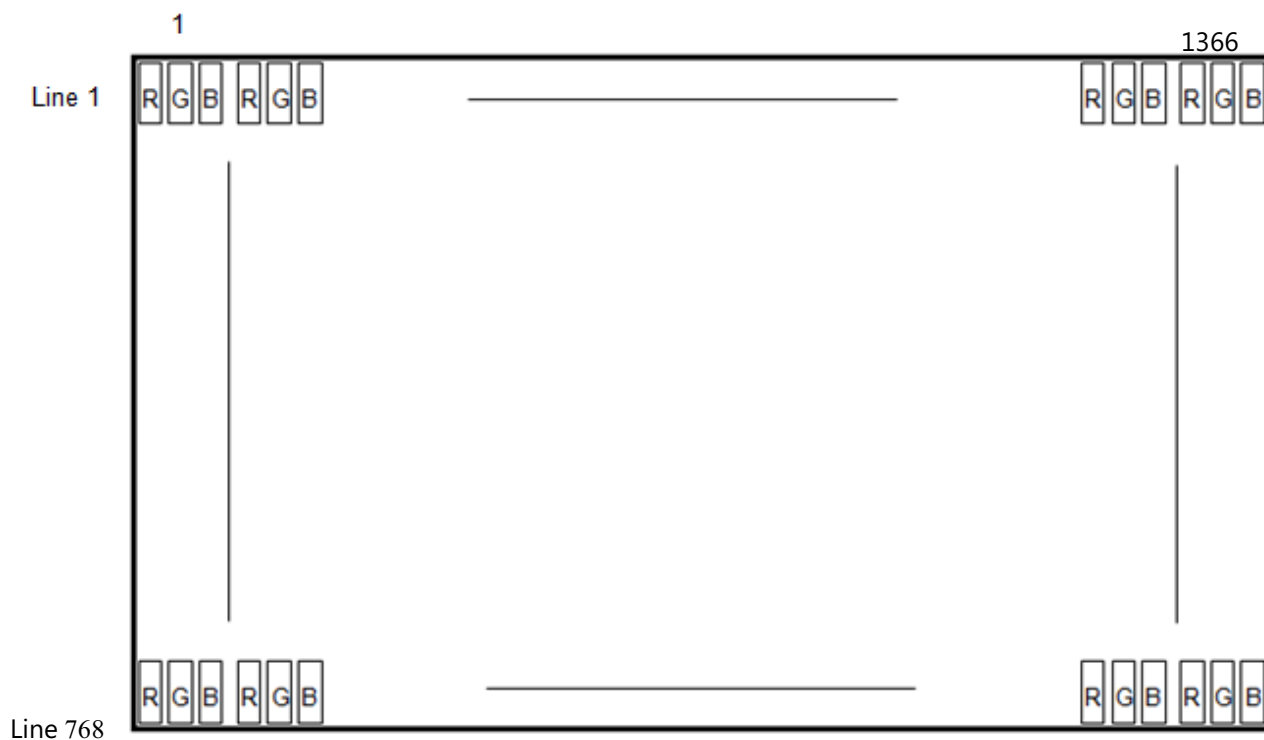
5.8 INPUT TERMINAL PIN ASSIGNMENT

5.8.1 INPUT SIGNAL & POWER

(LVDS, Connector : 20455-040E)

Pin	Symbol	Function
1	NC	Hot Plug Detect or No connection (optional)
2	LCD_VCC	LCD logic and driver IC Power (3.3V typ.)
3	LCD_VCC	LCD logic and driver IC Power (3.3V typ.)
4	VCC_EDID	DDC power
5	NC (WPN)	Reserved for the use by LCD manufacturer (WPN)
6	CLK_EDID	DDC clock
7	DAT_EDID	DDC data
8	RX0-	Negative LVDS differential data input for pixel
9	RX0+	Positive LVDS differential data input for pixel
10	H_GND	High speed ground
11	RX1-	Negative LVDS differential data input for pixel
12	RX1+	Positive LVDS differential data input for pixel
13	H_GND	High speed ground
14	RX2-	Negative LVDS differential data input for pixel
15	RX2+	Positive LVDS differential data input for pixel
16	H_GND	High speed ground
17	RXC-	Negative LVDS differential clock input for pixel
18	RXC+	Positive LVDS differential clock input for pixel
19	LCD_GND	LCD logic and driver IC Ground
20	NC	No connection
21	NC	No connection
22	LCD_GND	LCD logic and driver IC Ground
23	NC	No connection
24	NC	No connection
25	LCD_GND	LCD logic and driver IC Ground
26	NC	No connection
27	NC	No connection
28	LCD_GND	LCD logic and driver IC Ground
29	NC	No connection
30	NC	No connection
31	BL_GND	Backlight ground
32	BL_GND	Backlight ground
33	BL_GND	Backlight ground
34	NC	Hot Plug Detect or No connection (optional)
35	BL_PWM_DIM	Signal input for the system PWM for dimming
36	BL_ENABLE	Backlight on/off
37	APS_EN	APS on/off or No connection (optional)
38	BL_PWR	Backlight power
39	BL_PWR	Backlight power
40	BL_PWR	Backlight power

6. PIXEL FORMAT





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7. OUTLINE DIMENSION

Refer to the next page

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8. RELIABILITY TEST

Item		Condition	Time/Cycle
HTOL		55 °C	500 hrs
LTOL		-5 °C	500 hrs
HTS		70 °C	500 hrs
LTS		-25 °C	500 hrs
THB		50 °C, 90%	500 hrs
WHTS		60 °C, 75%	500 hrs
T/C		-40 °C/30min ~ 65 °C/30min	50 cycles
ESD	Non-operating	CDM : 150pF, 330Ω, 9point, 3 times/point	±10kV
	Operating	Contact : 150 pF, 330Ω, 100point, once/point	±8kV
		Air(non-contact) : 150pF, 330Ω, 100point, once/point	±15kV
Box Vibration (Non-operating)		5~200Hz, 1.05Grms, 2hr/Y	1time
Shock (Non-operating)		240G, 2msec, ±XYZ	30min/axis
HINGE		10~170°, Open/Close 2sec, Pause1sec	30Kcycle
Altitude		-40~50 °C, 0~45,000ft	72.5Hr

[Result Evaluation Criteria]

Under the display quality test conditions with normal operation state,
these should be no change which may affect practical display functions.